AD-A042 943 DEFENSE SYSTEMS MANAGEMENT COLL FORT BELVOIR VA F/G 9/2
HIGH ORDER LANGUAGE CONTROL FACILITY.(U)
MAY 77 B D BLOOD

UNCLASSIFIED NL

|OF|
AD
A042943

END
DATE
FILMED
9-77
DDC

DEFENSE SYSTEMS MANAGEMENT COLLEGE

PROGRAM MANAGEMENT COURSE
INDIVIDUAL STUDY PROGRAM

HIGH ORDER LANGUAGE
CONTROL FACILITY

STUDY PROJECT REPORT
PMC 77-1

Benjamin D. Blood, Jr.
Major USA

FORT BELVOIR, VIRGINIA 22060

HIGH ORDER LANGUAGE CONTROL FACILITY

Individual Study Program

Study Project Report

Prepared as a Formal Report

Defense Systems Management College

Program Management Course

Class 77-1

by

Benjamin D. Blood, Jr.
Major USA

May 1977

Study Project Advisor
LCDR Sue Anderson, USN

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER / 2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) HIGH ORDER LANGUAGE CONTROL FACILITY	5. TYPE OF REPORT & PERIOD COVERED Student Project Report 77-1 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) BENJAMIN D. BLOOD, JR.	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS DEFENSE SYSTEMS MANAGEMENT COLLEGE FT. BELVOIR, VA 22060	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS DEFENSE SYSTEMS MANAGEMENT COLLEGE FT. BELVOIR, VA 22060	12. REPORT DATE Student Project Report 77-1 13. NUMBER OF PAGES 35
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

UNLIMITED

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

SEE ATTACHED SHEET

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

SEE ATTACHED SHEET

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DEFENSE SYSTEMS MANAGEMENT COLLEGE

STUDY TITLE:

High Order Language Control Facility

STUDY PROJECT GOALS: To determine why an HOL control facility should exist, how it should be organized, what should its functions be, whether there should be separate control facilities for each DOD HOL or only one, and when should a control facility be established for the DOD HOL Program.

STUDY REPORT ABSTRACT: Recent DOD studies that have dealt with the problem area concerning the proper management of computer resources have made several recommendations. One is that high order languages (HOL) should be used to develop software so long as the number of different HOL is constrained and those remaining are carefully controlled. The purpose of this study is to specify the organization and functions of a HOL Control Facility and to discuss some of the issues concerning the implementation of such a facility for the DOD HOL Program. This study resulted from a synthesis of information available in the literature and from the author's experience as part of the DOD HOL Program. The study concludes that control facilities are necessary for all DOD approved HOL, that control facilities for existing DOD approved HOL will remain separate entities under the various military departments, that the control facility for the new DOD HOL should be a jointly manned and supported facility set up as soon as possible, and that the facility should use the ARPANET and become part of the National Software Works.

Subject Descriptors: Computer Software, Computer Languages, High Order Languages, Control Facilities

NAME, RANK, SERVICE	CLASS	DATE
BENJAMIN D. BLOOD, JR., MAJ, USA	PMC 77-1	9 May 1977

EXECUTIVE SUMMARY

A problem area that continues to have few easy and too often even viable solutions is that which encompasses the development and maintenance of computer software. One of the principal conclusions resulting from recent DOD-sponsored studies was that the use of high order computer programming languages (HOL) enhances the reliability and maintainability of computer software as compared to machine oriented language. This fact is true only so long as the number of different HOL is constrained and the HOL remaining are carefully controlled. The purpose of this study is to specify the organization and functions of a HOL Control Facility and to discuss some of the issues concerning the implementation of such a facility for the DOD HOL Program. This study reviews the results and current status of the DOD HOL Program. It then specifies the mission, organization and functions of an HOL control facility. Finally it discusses implementation issues concerning the establishment of a DOD HOL Control Facility. The study concludes that control facilities are necessary for all DOD approved HOL, that control facilities for existing DOD approved HOL will remain separate entities under the various military departments, that the control facility for the new DOD HOL should be a jointly manned and supported facility set up as soon as possible, and that the facility should use the ARPANET and become part of the National Software Works. This study can be of significant benefit to the members and sponsors of the DOD HOL Working Group. This work can serve to aid and stimulate more detailed planning for a joint HOL Control Facility. It can also be of interest to those personnel in a program office who are responsible for the successful acquisition of computer software.

TABLE OF CONTENTS

LIST OF FIGURES

SECTION I

INTRODUCTION

Purpose of the Study

If the sum total of DOD computer software acquisition were measured by the traditional system parameters of cost, schedule and technical performance, the DOD software program manager would have been fired for seriously breaching his thresholds long ago. Costs for software in DOD in 1973 (15)[1] were estimated at $3 to $3.5 billion annually and are increasing as a percentage of the total cost for computer systems. Software is too often late, causing major slippage in program schedules. Technically software is often unreliable, difficult to modify, not easily transported to other systems and unresponsive to user needs.

This familiar litany of difficulties with computer software has been the subject of much discussion in both the commercial world and within the US Government. DOD recognized these problems and sponsored various studies which were completed in 1975. The Joint Logistics Commanders study (14:93), in particular, provided findings and recommendations concerning approaches to help solve some of these problems. One of their major findings was:

> SR-3A EVALUATION OF PROGRAMMING LANGUAGES AND RECOMMENDED LANGUAGE STANDARDS
>
> Finding: The programming language selected for a given system application has a significant impact on the ultimate reliability of the software developed. A Higher Order Language (HOL) enhances reliability over a Machine Oriented Language (MOL) ...

[1]This notation will be used throughout the report for sources of quotations and major references. The first number is the source listed in the bibliography. The second number, if used, is the page in the reference.

> The proliferation of programming languages (either HOL or MOL), however, is a major contributor to both software reliability and maintainability problems. From the reliability viewpoint, language proliferation makes the language learning process difficult, and hence leads to coding errors, discourages the development of adequate test and support tools around each language; and reduces management visibility and control over the software design and development activity. From the maintenance viewpoint, language proliferation complicates the institutional control over language features; and magnifies the documentation, training, and other costs in proportion to the number of languages in use.

Their recommendations as a result of this finding were:

1. To encourage the use of HOL by restricting the use of MOL.
2. To discourage the proliferation of HOL currently being used in DOD.
3. To establish control facilities for DOD authorized HOL.

At the same time as the above study efforts were nearing completion, two related initiatives were begun. The first was the establishment of a DOD Weapons System Software Management Committee[1] in December 1974. It was to identify and solve the problems associated with weapon system computer resources throughout their life cycle. The aforementioned studies were major inputs to this committee. Its first efforts culminated in the publication of a software management plan. HOL policy actions in that document are summarized in Figure I (3:II-4). In turn a DOD Directive concerning the management of computer resources in major defense systems was issued in April 1976. A major subparagraph covered HOL (6:3). It stated:

[1]Also later known as DOD Software Management Steering Committee and finally as DOD Management Steering Committee for Embedded Computer Resources (MSC-ECR).

Figure I

Software Lang[illegible]tandardization & Control

IMPLEMENTATION OF POLICY ACTIONS

ACTION	VEHICLE	OPR	TIME (YEARS)	$K REQUIRED RESOURCES
MOL SUPPRESSION	DODD XX	OSD	0.5	- -
ESTABLISHMENT OF APPROVED HOL				
INTERIM STANDARDS	DODI XX	OSD	0.5	- -
LONG TERM STANDARDS	DODI XX	OSD	3.0	$14,000
HOL CONTROL FACILITY	DODD XX DODI XX	OSD	3.0	$2M/YR

> Software Language Standardization and Control. DoD approved High Order Programming Languages (HOLs), will be used to develop Defense system software, unless it is demonstrated that none of the approved HOLs are cost effective or technically practical over the system life cycle. Each DoD approved HOL will be assigned to a designated control agent who will be responsible for such activities as validating compliance of compiler implementations with the standard language specifications, gathering data as to the use of the language, and for disseminating information, compilers, and tools. The designated control agent will also be responsible for assuring language stability. . .

In November 1976 a DOD Instruction (8) was published designating the current list of DOD approved HOL and their control agents.

The second initiative was the establishment by DDR&E of the DOD High Order Language (HOL) Working Group in January 1975 (4). Its purpose was to determine the feasibility of establishing a minimal set of common high order programming languages for use in major defense systems. Its thrust was to establish HOL requirements and to determine the best approach to meet these requirements. It was not necessarily limited to adoption of an existing HOL. Its current actions indicate a modification to an existing HOL will result. This HOL will eventually be added to the list of DOD approved HOL and will require a control agent.

Whether it is an existing approved HOL or an eventual addition to the list, some type of control facility must be established. How should a HOL control facility be organized? What should its specific functions be? Should there be separate control facilities for each HOL or should only one exist? This study will address these questions and will provide my view of the proper answers.

Scope and Limitations

Although much of the background material in this report is commonly associated with embedded computer resources, the results should be equally applicable to control of HOL used by the traditional ADP community. Too often it is argued that the split between the embedded computer community and the ADP community continues for all aspects of computer systems. I believe, however, that the difference is essentially contained in separate management philosophies and perhaps some requirements for specific software. Otherwise, the differences seem to be artificial. Thus, this report does not differentiate between HOL control facilities for embedded computer systems versus ADP systems.

There are certain methods already established for the control of COBOL and FORTRAN, DOD Standard HOL. These systems are geared to national standards and coordinated development as determined by ANSI and associated groups, e.g., CODASYL. Thus, any DOD control facility that encompassed these languages would have to include established channels for the control of these HOL.

Organization of Report

This report begins with a quick look at the general problems inherent in computer software acquisition and use. It then progressively reviews DOD initiatives to solve these problems in the area of HOL and suggests an approach for an area that has not been completely addressed yet: HOL control facilities.

Section I is essentially a historical review of recent DOD actions to improve the acquisition and use of computer resources with emphasis on HOL. It also contains the scope and limitations of this report.

Section II reviews the work of the DOD HOL Program since it will directly impact and influence the functions and organization of a HOL Control Facility. The current HOL control facilities for COBOL and CORAL-66 are also briefly reviewed to provide background on the control of existing HOL.

Section III states and explains the recommended functions of any HOL control facility.

Section IV discusses implementation issues and conclusions concerning the establishment of a DOD HOL control facility. Topics covered include its location as an organizational entity, the merits of merging all or some portion of the current DOD approved HOL facilities, when the new HOL control facility should be established, and its relationship with the ARPANET/proposed National Software Works. At the end, a summary of the conclusions reached in this paper and areas for further study are stated.

SECTION II

BACKGROUND

In the first section of this report a framework concerning general DOD actions to improve the acquisition and use of computer resources was established. Then the focus shifted within this framework to the value of using HOL and the need to control HOL to insure optimum usage. This background would be incomplete if we did not explore more thoroughly the basis for and the status of the current DOD HOL Program as well as the standardization, development and control situations for other current HOL.

HOL Proliferation

Until the recent interim list of HOL was published, there were relatively few constraints on programming language use in DOD. The business-oriented ADP community was required to use COBOL and the scientific ADP community was required to use FORTRAN. Communications software and many weapon system developments depended upon assembly language. Some weapon system software development was done in HOL. The Air Force relied on JOVIAL (J3), the Navy on CMS-2 and the Army on TACPOL when HOL were used.

Since the benefits of using HOL were recognized and the then current HOL were felt to be inadequate, various additional HOL development efforts were started. A partial list would include TACPOL-II, JOVIAL (PATRIOT) and PDL by the Army; SPL/1, TRIDENT HOL, and CS-4 by the Navy; JOVIAL J73 and JOVIAL J3B by the Air Force; and COL by DCA. This proliferation and its attendant cost was soon recognized by the Military Departments and DOD. As

a result during 1974 the adoption of a common programming language for use in the development of major defense systems was proposed.

Common DOD HOL

The ensuing effort at the joint level to develop a common programming language followed the traditional acquisition process of any system. The need had been established by the Military Departments and the equivalent of a Study Advisory Group was established by DDR&E. It was called the DOD HOL Working Group. Its chairman was from DDR&E and its membership was from the Military Departments, DCA, NSA and DARPA. Its course of action was to establish the requirements for a HOL, compare these requirements with existing HOL, choose a development alternative and implement the chosen HOL approach. At the same time, any other work to implement other new HOL was stopped by DDR&E.

The first phase - requirements identification - began in January 1975 with the preparation of a "strawman" requirements document by the DOD HOL Working Group. It was a preliminary document which primarily illustrated the level of detail desired with incomplete and sometimes inconsistent requirements. It was sent to the Military Departments, other government agencies, industry and the academic community for comment. The results of this review were gathered and merged with the strawman to produce a more consistent and complete requirements document called a "woodenman." Although this document was greatly improved, it was still tentative. The woodenman was again widely distributed for comment. The result of this second iteration of review and consolidation was a firm set of requirements in January 1976 called the "Tinman." It was the basis for the next phase - comparison of

existing HOL with requirements. The equivalent of a Milestone 0 approval for the Conceptual Phase was provided by DDR&E on 10 May 1976 (5).

Development alternatives ranged from selection of an existing HOL, to evolutionary development of an existing HOL, or to design of a completely new HOL. Ideally the least costly approach would be to select an existing HOL that required few or no changes. The candidate languages proposed for evaluation purposes could obviously not cover the entire spectrum of available HOL since these numbered in the hundreds. A preliminary screening limited the candidates to existing appropriate DOD HOL, other well known HOL, and certain HOL that had special features and technological innovations. Evaluations of these languages versus the Tinman requirements were conducted via six contracts as well as by other interested groups. In addition to comparing requirements to the existing HOL, comments on the feasibility of modifying the existing HOL to bring it into compliance with requirements, identification of unnecessary existing features and comments on the completeness of the requirements in light of the evaluation were solicited. These evaluations were completed in December 1976.

As the evaluation effort progressed, three other program management initiatives were completed. The HOL Working Group was established as a formal technical panel under the auspices of the Management Steering Committee for Embedded Computer Resources (MSC-ECR) in mid-1976 (6:2-4). The second initiative involved the preparation and publication of a Program Management Plan (PMP). It was formally published in January 1977 (7). The third initiative was the publication of the interim list of DOD approved HOL (8) in November 1976.

The HOL Working Group with appropriate consultants consolidated the results of the various evaluation efforts into a report (1:3). Its findings were:

> Among all languages considered none was found that satisfies the requirements so well that it could be adopted as the Common Language.
>
> All evaluators felt that the development of a single language satisfying the requirements was a desirable goal.
>
> The consensus of the evaluators was that it would be possible to produce a language within the current state of the art meeting essentially all the requirements.
>
> Almost all the evaluators felt that the process of designing a language to satisfy all the requirements should start from some carefully chosen base language.
>
> Without exception, the following languages were found by the evaluators to be inappropriate to serve as languages for a development of the Common Language: FORTRAN, COBOL, TACPOL, CMS-II, JOVIAL J73, JOVIAL J3B, SIMULA 67, ALGOL 60, and CORAL 66.
>
> Proposals should be solicited from appropriate language designers for modification efforts using any of the languages PASCAL, PL/I, or ALGOL 68 as base languages from which to start. These efforts should be directed toward the production of a language that satisfies the DOD set of language requirements for embedded computer applications.
>
> At some appropriate time some choice should be made among these design efforts to determine which are most worthy of being continued to completion.

It should also be noted that as a result of these evaluations and other inputs, a new requirements document was produced called the Ironman (10). It was prepared in the form of a language specification.

These results were presented to the MSC-ECR at the end of January 1977. Approval to proceed with parallel design efforts was received. This

could be considered the equivalent of Milestone 1 approval to proceed into the Validation phase of a major system. Present efforts are centered around completion of a procurement package for parallel design efforts, release of the RFP and source selection. Currently the HOL control facility for this effort is scheduled to be established in August 1978, based on the results of establishing control facilities for the interim DOD approved HOL. Some of these control facilities are in the process of being established now.

COBOL Standardization and Control

COBOL is a language on the interim list of DOD approved HOL. Since it is a language that is subject to national standards efforts, its control is different from DOD-unique HOL. The American National Standards Institute (ANSI) publishes a standard defining document as per the approval of its Committee on Computers and Information Processing (X3) which consists of government, industry and other users. A technical committee for COBOL (X3J4) recommends the initial standard and/or a major revision to the standard. Again this technical committee has representatives from government, industry and other users. The latest standard was promulgated in 1974 (ANSI X3.23-1974).

U.S. Government standards in this area are promulgated by the National Bureau of Standards, Department of Commerce. They are known as Federal Information Processing Standards (FIPS). The FIPS publication for COBOL (FIPS PUB 21-1) cites the ANSI COBOL standard. It also specifies policy for Federal government use of the HOL. This in turn is implemented and broadened by DOD Directive and Military Department regulations. In

particular, DOD through the Navy operates a Federal COBOL Compiler Testing Service (FCCTS) to validate that COBOL compilers indeed meet the ANSI COBOL Standard. A COBOL compiler must now be validated before it can be procured.

Development of the COBOL language is done by an organization called the Programing Languages Committee (PLC) of the Conference on Data Systems Languages (CODASYL). This committee has representatives from government, industry and other users. The results of its deliberations are published in the CODASYL COBOL Journal of Development. This journal is the primary basis for the deliberations of the ANSI committee for standards changes. The Military Departments have representatives on both the ANSI and CODASYL committees.

CORAL 66 Standardization and Control

CORAL 66 was developed at the Royal Radar Establishment, United Kingdom (UK) in the 1960's. It was established as the standard programming language for real-time systems and computers in weapon systems in 1970. It was adopted as an English national standard in 1973. It has gained wide acceptance in the English commercial sector for similar type programming. It is supported by the Department of Industry as well as the Ministry of Defence (MOD).

The MOD has a controlling body similar to the DOD MSC-ECR called the Interestablishment Committee on Computer Applications (IECCA). The Royal Radar Establishment has a Computing Standards Section which serves as the Control Facility for CORAL 66. In turn the CORAL 66 group is a combined users and implementors group (12:3-9). Much of the organizational structure and historical development of CORAL 66 has been helpful in the DOD HOL effort.

DOD HOL Standardization and Control

The interim list of DOD approved HOL are standardized and controlled in two ways. The first is via DOD affiliation with national efforts such as explained previously on COBOL. FORTRAN standardization and control is similar. The second concerns DOD-unique HOL where individual military departments have published appropriate defining documents and have been appointed as control agents. In essence each military department is creating separate HOL facilities for the languages under their cognizance. Project Manager, Army Tactical Data Systems (PM, ARTADS) is establishing a control facility for TACPOL. Naval Air Systems Command (NAVAIR) is establishing a control facility for SPL/1. Naval Electronics Systems Command (NAVALEX) is establishing a control facility for CMS-2. Air Force Systems Command is establishing its control facility for both dialects of JOVIAL (2) at the Rome Air Development Center.

While there is some dialog between the Military Departments, each of these HOL control facilities will be established differently. Some will only emphasize maintenance of the HOL as it is, others will pursue development of the HOL, and still others may emphasize other HOL related tool development. At the same time if the DOD HOL program is going to establish an HOL control facility, should it copy an existing facility or pursue some optimum set of functions? The documented organizational structures and functions of control facilities for COBOL, FORTRAN, CORAL 66 etc. and the emerging HOL control facilities for DOD approved HOL can serve as a basis for my perception of an HOL Control Facility.

SECTION III

ORGANIZATION AND FUNCTIONS

Mission

An HOL Control Facility is an organizational entity composed of procedures, personnel and facilities to manage and control a high order language and its associated libraries, translators and other related tools throughout their life cycle. Its mission is to:

1) insure HOL stability via standardization procedures.

2) develop and maintain state-of-the-art translators, related tools and libraries.

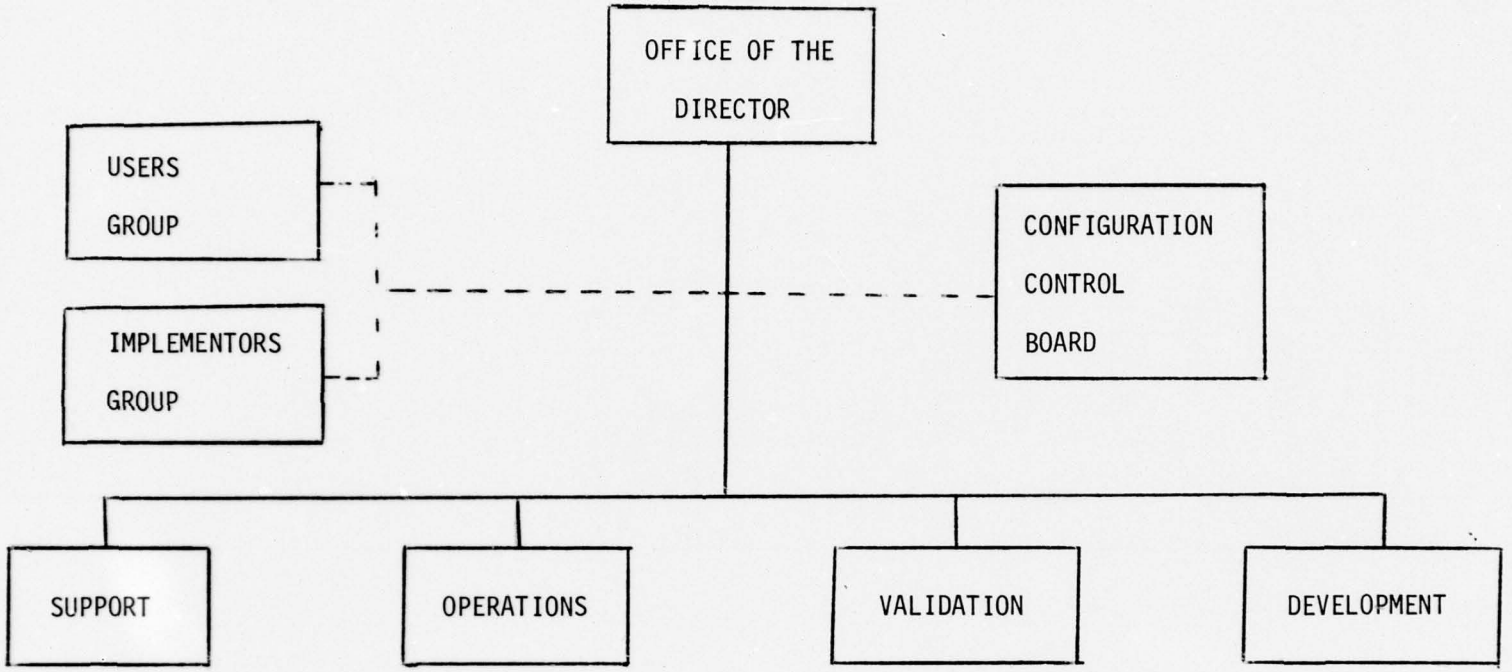
3) promote the use of the HOL.

4) *foster long term research and development in HOL.*

Organization

After a careful review of the many functions possible for an HOL Control Facility, they have been grouped in accordance with the organizational chart at Figure II. There are two types of relationships indicated on the chart. The first type is the organizational elements of the facility itself which are connected hierarchically by solid lines. The second is the special groups not under control of the director which either provide direct channels to users and implementors or provide independent means to control the HOL.

FIGURE II



HOL CONTROL FACILITY

ORGANIZATIONAL CHART

Special Groups

The Users Group

The users group would consist of representatives from programming organizations which develop applications software using the HOL support software. They would provide input on problems with the HOL itself, problems with compilers and other existing support software, and needs for new support software. In turn information on the current status of HOL Control Facility development programs could be presented and seminars or other short-duration training could be held. Meetings would be scheduled as often as needed. Occasionally joint meetings with the implementors group would be held to provide a means for exchange of ideas and information between the two groups.

The Implementors Group

The implementors group would consist of those organizations external to the HOL Control Facility who would be developing HOL-related software such as translators. Conceivably this could be done by IR&D money of contractors, independent research by universities, as well as specific DOD contracts such as unique library routines required by a program office. In order to insure conformance with standards, to receive feedback on problem areas, to maintain information on special library routines and to promote academic use of the HOL, such a group should be formed. Meetings would be scheduled as often as needed.

The Configuration Control Board (CCB)

Configuration control would be established by tailoring the military standard on configuration control (9) for computer software. The board

would be chaired by the Director of the HOL control facility. Its membership would include users and staff from both the Operations and Development elements of the HOL control facility. Configuration identification would be maintained by the Operations element librarian. Valid change requests would be received by Operations, preliminary analysis would be performed by the Development element and meetings would be scheduled by Operations depending on urgency of changes. Changes would be reviewed and further analyzed by the CCB. Its decisions on the change, their classification, priority and the rationale for the decision would be prepared by the librarian and disseminated. Inclusion of the changes would then proceed either by the Development element or a contractor. Upon completion the librarian would be informed so that configuration identification could be updated and its status transmitted to all concerned.

Functions

Office of the Director

Manage all of the activities of the control facility - Each of the organizational elements below the director have been delegated various functions. These will be explained in detail for those elements. His decisions affect internal policies, procedures and priorities.

Serve as the interface to higher headquarters - Advises higher headquarters on matters affecting HOL Control Facility and requests assistance for support functions not inherent to the HOL Control Facility.

Chair the CCB.

Support

This element performs that set of related tasks which support the accomplishment of the assigned mission.

Provide administrative services - These include operating a distribution center; acquiring regulations, forms and other external publications; maintaining a technical library, point of contact on public information matters; providing printing and duplicating.

Plan, budget and manage the financial resources - This function includes preparation of documents necessary for funding from higher headquarters as well as internal control of funding use. Also included are manpower authorization activities.

Provide military and civilian personnel support - These are the traditional functions of requisitioning or recruiting personnel, administering pay and personnel record inputs, controlling the preparation of personnel evaluations by appropriate supervisors.

Provide contracting support - The potential for contracts to do large portions of the control facility work is high. Processing of the procurement package, monitoring of the contracts and coordination with contracting officers would be provided.

Provide facilities management - These are the functions of allocating building space, providing office equipment providing consumable supplies, coordinating transportation requirements, providing facilities maintenance.

Provide computer hardware resources - This function would depend on the actual computer time needed for the HOL Control Facility and the

availability of external resources. Normally, you would expect that the HOL Control Facility would tie in to a large system via remote batch and interactive terminals. If requirements were such that a stand-alone capability were needed, all the aspects of acquiring and operating a computer facility would ensue. It is not within the scope of this study to explore these needs in detail. Section IV discusses the possible use of the ARPANET and affiliation with the National Software Works.

Operations

This element performs that set of related tasks which concern overall planning, control of standards, training and day-to-day contact with users, higher headquarters and others.

Prepare and publish an HOL Control Facility Master Plan - This document would be the basis for all activities of the control facility. It would merge the financial and personnel planning of Support, the technical planning of Development and Validation with the day-to-day work of Operations. This document would be updated periodically.

Prepare and publish HOL control facility operational procedures - Such procedures are not only essential for smooth internal operations of the control facility, but also allow proper external relations with users, implementors, contractors and higher headquarters. They would cover much of what is being functionally described in this study.

Prepare and publish a formal HOL defining document - This document is essentially the HOL specification which will be used as the standard. Such a document will include a clear and unambiguous definition of semantics as

well as syntax. Backus-Naur Form (BNF) is commonly used for context free syntax, but context-sensitive syntax and semantics do not have such well accepted forms of formal definition. Much work is currently being done in this latter area (11). Until research is complete in this area, one of two interim approaches may be feasible. The first is to use a combination of English and the actual HOL constructs themselves a la LISP or SIMULA 67. The second is to pursue using the best current approach such as the axiomatic approach espoused by Hoare (12:4-12). This document would be periodically updated as changes, additions and deletions are approved by the CCB.

Prepare and publish user manuals for the HOL and its translators - It would be nice if the above defining document were so clear that it would serve the user as well as being the standard. Invariably this is not the case. A separate set of documentation should be prepared for reference needs and training programs. Often this takes the form of a tutorial introductory description and a more formal, in-depth description. These documents would also be updated as changes are approved by the CCB. If the HOL facility would provide access to the HOL and its translator via an ARPANET/National Software Works approach, on-line documentation would be prepared and updated.

Prepare and publish specifications and user documentation for utilities and library routines - In most cases these utilities/library routines would be provided by two sources - the internal development activity of the facility and users who develop their own specific needs.

Those routines which could be used by more than one user would be documented and controlled via the CCB. Again formal specifications and user documentation of both hard copy and on-line types would be needed.

Establish and maintain an interface with users - This function would include the establishment of a users group and the sponsorship of, as a minimum, annual meetings of all users. A day-to-day interface with users concerning problems with the HOL, its translators and the utilities/library routines as well as disseminating information and providing advice on their use is needed. A quarterly newsletter would be prepared, published and distributed to support this interface.

Gather statistics and other data as to the use of the HOL - This function would include gathering data on the translators, utilities/library routines and other software tools as well. Analysis of information on usage could indicate areas where optimization might be necessary. Analysis of information on problems could aid not only in their solution but also would help to determine priorities for further work. This function would also include the maintenance of a complete file on the characteristics of all the users, e.g., computer hardware configuration, support tools in use, etc.

Prepare and conduct a training program for HOL users - The primary tool of such a program would be the aforementioned user documentation. This would be included in an overall course syllabus along with course schedules, teaching examples and problems and tests. Courses should be

established for various levels of programmer capability, e.g., beginning and advanced, and should cover translator, utility/library routines and other tools as well. Such training would normally be conducted at the facility, but could be provided at the user installation when justifiable.

Establish a configuration control board - The agenda and meeting schedule would be prepared. The facility software librarian in Operations would be the primary interface for all matters concerning standards. Specific functions of the CCB are explained above.

Recommend DOD policy changes concerning HOL - This might include such areas as the required information necessary for support software in contracts for major weapon systems, i.e., required use of a specific HOL, certification of vendor provided translators, utility/library routines and other tools, etc.

Monitor a DOD-wide program to insure compliance with standard HOL.

Serve as a representative to national and international HOL groups - This function might equally well be in Development. If the emphasis is on existing standards as part of ANSI work, it would probably have a representative from Operations. If the emphasis was on the development of an improved HOL, then Development would provide the representative.

Validation

This element performs that set of related tasks which validate and/or verify that support software for the HOL meet the current standards. This element should remain separate from other elements of the control facility to insure that its efforts are truly independent.

Prepare a thorough and complete set of compiler validation tests - These tests should test all aspects of a compiler to include language features, error detection, compliance with standard diagnostics, and implementation quality (size, speed, object code efficiency). Preferably such tests could be prepared for testing each compiler by a HOL compiler validation tool such as used by the Air Force with JOVIAL (2:4-1).

Test and certify all translators for the HOL - Translators will conform to the standard as specified in the defining document and will be free from known errors prior to certification for use in DOD. Compilers submitted for certification (whether by the government or vendors) will be tested in a similar manner. Test results will be documented by a formal report.

Test and certify utilities/library routines and other tools - These tools should be written in the HOL. This fact should help insure the correctness of the code. These other support software tools would have to be validated against specifications like translators.

Development

This element performs that set of related tasks which concern all aspects of the actual development of new support software and maintenance of existing support software.

Prepare and publish a translator implementors guide - This guide and the HOL defining document would provide translator implementors most of the information necessary for developing a compiler. Such requirements as the translators for an HOL will be written in the HOL, designation of a

standard set of diagnostics, no subset or superset implementations, etc. (10:23) are examples of information in such a guide.

Establish and maintain an interface with implementors - This function would include the establishment of an implementors group and the sponsorship of, as a minimum, annual meetings of all implementors. A day-to-day interface with implementors concerning problems with implementation of the translators and the utilities/library routines as well as disseminating information and providing advice on implementations is needed. A portion of the quarterly newsletter would address this area.

Assess impact of changes, additions or deletions to HOL - This work is primarily in support of the CCB and would be done on changes to translators, utilities/library routines and other support tools. The results would also be used to estimate cost and work schedules for internal development or contracts.

Develop and maintain translators and other support software - This would include the life cycle development and maintenance of compilers, utilities/library routines, interactive source language editors and symbolic debuggers, test case design advisors, statistics collectors, text editors, loaders, etc. (13). Each of these support software tools would have standard specifications, would be verified and would be subject to the CCB process for changes.

Identify a formal tool or method to prove complete compiler correctness - Verification of compilers is dependent on the state-of-the-art of the HOL such as an inherent assertion capability and/or the use of formal semantics specification in the defining document. The development of such

a tool would not only aid proof of compiler correctness but also program correctness. Current work is only capable of achieving assurance of partial correctness (16 & 17). This tool would be used by the Verification element when complete.

Establish a machine independent compiler - In essence this tool would be some variation of a compiler writing tool. The tool would contain a standard front end (scanner, parser, error handling, optimization and semantic routines) with a standard intermediate language. The code generator portion would have to be hand prepared for each target machine. This system would be available to any hardware proponent or other developer to construct compilers quickly. Implementation improvements could then be developed and incorporated as necessary. Eventually research may even discover a way to automate the code generation portion.

Sponsor research work to develop a new HOL - The state-of-the-art in language research is continually advancing. New HOL capabilities (abstract data types) and new computer architectures will eventually develop which will make current HOL obsolete. New HOL requirements that cannot be incorporated in the current HOL must be part of the specification for the next generation HOL. Work at academic institutions and elsewhere should be sponsored to develop new HOL capabilities and other related research.

SECTION IV

IMPLEMENTATION ISSUES AND CONCLUSIONS

Since the planning for control facilities for existing HOL should have largely been completed, the intent of this study is to focus on the HOL control facility that is intended to be established in August 1978 by the DOD HOL Working Group. The planning for such a facility should begin now if it is to be properly implemented.

Various issues concerning the implementation of such a control facility will arise before detailed planning can proceed. These issues should be surfaced and eventually settled. My perspective on some of these issues may help this process.

Location

Why couldn't the people and facilities for the DOD-unique HOL control facilities be merged at one location? Wouldn't such a merged facility then eventually be able to assume responsibility for the new DOD HOL? Even though the individual control facilities control separate HOL, many of the tools and much of the work would be similar. In many aspects the economies of scale involved in a joint HOL control facility would be less costly. A properly sized computer facility would be large enough to fulfill the most sophisticated requirements, yet would be less costly than use of individually separate computer capability for each HOL. Overhead costs could be reduced for administrative and support areas. Coordinated research and other overall planning would be improved. All DOD users would only have to go to one location for HOL support.

On the other hand certain HOL might be de-emphasized because of a small user base or because of a comparatively lesser capability. This is not necessarily bad overall, but certainly would be for the existing users. Centralized control at DOD level would limit the control each military department now has individually. Since each military department has much sunk investment in present software, it would be loath to relinquish control of their HOL. I believe there may be good arguments for a merger of HOL facilities now, but that the realities of present military department attitudes would require the continuation of separate HOL control facilities for the present DOD-unique HOL.

The new DOD HOL control facility, however, can be organized as a joint facility. In fact, it must be, if it is to have users throughout the DOD community. It should be jointly manned and preferably have its own computer resources for development and validation of support software. It could be physically located at any military installation that had existing facilities that could best accommodate the needs of the HOL control facility. Organizationally, to forestall factional problems, it should be directly subordinate to DDR&E[1]. It could have a relationship similar to that between TRI-TAC and DTACCS. It would still be guided by the MSC-ECR and its technical panel, the DOD HOL Working Group.

[1]As of 20 April 1977 OASD(I&L) was disestablished and DDR&E assumed responsibility for all acquisition activities as well as research and engineering. Note that the appointment of a single organizational entity at OSD level to provide policy and guidance for all DOD computer resources would be OASD(C) if congressional guidance were followed.

Time of Establishment

Even though the target date is August 1978 the sooner the DOD HOL control facility is established the better. Presently much of the DOD HOL Working Group work is being done part time by military department members and other representatives. Few can be considered as working full time on this program. Individuals, even within military departments, are separated geographically and only interact together at monthly or bi-monthly meetings, via phone conversations or ARPANET messages. This leads to improper coordination, long lead time for working group actions, incomplete preparation of documents, procurement packages, etc. Viewed in this light, it is surprising that so much has been accomplished thus far.

If this were a major system in a military department, the planning for the organization, manning and facilities for a program office would have been completed. The program office would have then been established during the validation or prototype development phase. This is the phase that the DOD HOL Program has been in since the end of January 1977. A DOD HOL Facility which would act in a manner similar to a full time Program Management Office should be established as soon as possible.

Internal Organization and Functions

The organization and functions of the HOL Control Facility were specified in detail in Section III. These functions, particularly in the support area, would have to be tailored dependent upon support provided by the military installation at which the HOL facility is located, the number of HOL that are controlled and the relative priority of some of the

development activities. If the facility were also to assume Program Management Office responsibilities, the initial manning would be more comprehensive.

National Software Works/ARPANET

The ARPANET is a nationwide computer network designed both to explore network technology, and to interconnect and service various computer centers. Its key aim is to allow the accessing of software, services and data from any place in the network. It is composed of two sets of interconnected computer subsystems. One consists of the computers that will provide the computational services, and the other of the computers that service the communications needs of the network.

The National Software Works (NSW) will be a capability, resident on the ARPANET, intended to support the development, use, maintenance, modification, verification, and storage of programs and data. It is principally aimed at the development of software by using available support tools. NSW is intended to ease both the administrative and technical aspects of these activities. It provides mechanisms for fiscal and access control in the operation of software projects, and also access and storage convenience to programmers for the management of their files.

The HOL Control Facility could use the ARPANET/National Software Works in a number of ways. Its own computer facility could serve as a tool bearing host for users. It could verify compilers on other host computers of different architectures. It could receive and send messages from users on the ARPANET. It could use its statistics gathering support software

directly in conjunction with user operational software. Until the advent of the National Software Works, the existing ARPANET would still serve for some of these needs.

Summary of Conclusions

1. HOL Control Facilities are not only desirable organizational entities but are required for all DOD approved HOL.

2. HOL Control Facilities for existing DOD approved HOL should remain separate and under the cognizance of the appointed control agents.

3. The HOL Control Facility for the new DOD HOL should be a jointly manned and supported facility which reports directly to DDR&E with the guidance of the MSC-ECR.

4. The HOL Control Facility should be established as soon as possible to more effectively accomplish the work of the DOD HOL Working Group.

5. The HOL Control Facility should be organized and function as specified in Section III.

6. The HOL Control Facility should use the ARPANET and become a part of the National Software Works.

Additional Areas of Study

This study has primarily concentrated on the organization and functions of an optimal HOL control facility. It has also addressed some other questions concerning the implementation of a DOD HOL facility. A detailed HOL Control Facility Implementation Plan should now be developed which would focus on such areas as the actual location of the DOD HOL Control Facility, exact number, grade and specialty of personnel to man

the facility, the actual computer resources required and available, joint allocation of funds for the facility by the military departments and the exact date the facility would begin operations.

BIBLIOGRAPHY

1. Amoroso, S., et al, "Report to the HOLWG," Language Evaluation Coordinating Committee, 14 January 1977.

2. Anderson, W., et al, "Language Control Facility (LCF) Study - Vol 1 & 2," Computer Sciences Corporation, December 1976.

3. "Defense System Software Management Plan," OASD(I&L), 19 March 1976.

4. DDR&E Memorandum, subject: DOD Higher Order Programming Language, 28 Jan 75.

5. DDR&E Memorandum, subject: DOD High Order Language Program, 10 May 1976.

6. DOD Directive 5000.29, "Management of Computer Resources in Major Defense Systems," April 26, 1976.

7. "DOD High Order Language Program Management Plan," 21 Jan 77.

8. DOD Instruction 5000.31, "Interim List of DOD Approved High Order Programming Languages (HOL)," 24 November 1976.

9. DOD MIL-STD-480, "Configuration Control - Engineering Changes, Deviations and Waivers," 30 October 1968.

10. "DOD Requirements for High Order Computer Programming Languages - Ironman," 14 Jan 77.

11. Dreisbach, T. A., et al, "High-Order Language Technology Evaluation" Intermetrics, Inc., 15 October 1976.

12. Enslow, P. H., et al, "Implementation Languages for Real Time Systems - Part 1, Standardization--Its Implementation and Acceptance," ERO-2-75-Vol. 1, 15 Apr 75.

13. Felty, J. L and Roth, M. S., "Software Support Tools," Intermetrics, Inc., 15 Oct 76.

14. "Findings & Recommendations of the Joint Logistics Commanders Software Reliability Work Group (SRWG Report), Vol. 1, Executive Summary, November 1975.

15. Fisher, David A., "Automatic Data Processing Costs in the Defense Department," Institute for Defense Analysis Paper P-1046, October 1974.

16. Lampson, B. W., et al, "Report on the Programming Language Euclid" 18 August 1976.

17. Robinson, L., et al, "The Verification of COBOL Programs," Stanford Research Institute, USACSC Report, March 1976.